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Residents' Perceptions of Water-Related Problems in the Mailiao Area, Taiwan

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Abstract

This study surveyed the residents in Mailiao, a town located on the central-western coast of Taiwan, about their perceptions of environmental issues associated with water. A six-item measurement was developed. The residents were certain of sixteen identified environmental problems. Acid rain, subsidence and over-pumping of underground water were the three most serious problems in the area. The residents believed that these problems will worsen in the next ten years. They also believed that technology can solve the problems. The residents agreed to alter their lifestyles in order to alleviate the environmental problems.

Keywords: Environmental change; water related issue; environmental perception

1. Introduction

Global warming has caused environmental problems around the world, many of them having to do with water: for example, icebergs are melting, the sea level is rising, and droughts, flooding, and snowstorms are more and more severe. Water appears on earth in a variety of forms (ice, steam, snow, liquid, etc.) and exists in different parts of the planet (ponds, streams, rivers, ocean, etc.). Different forms of water are constantly moving around the earth, and one of the most important areas that affects human life is where fresh water and salty water meet.

Coastal ecosystems are the most valuable natural systems in the world. They provide coastal protection, erosion control, food, carbon sequestration, and places for tourism and recreation, yet human

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beings continue to heavily develop the land along the coastlines, carelessly threatening the most precious ecosystems that they depend on for survival. The extreme climate effect is worsening the situation, and the coastlines of Taiwan have not been spared.

The land of the central-western coastal area of Taiwan was formed from the deposition of sediment as rivers flowed from the central mountains into the Taiwan Strait. Mailiao, a town located in this region, used to be an agricultural area, but has been suffering from many environmental problems, such as subsidence, erosion of the coastline, flooding, and ocean pollution. Residents here usually engage in livelihoods such as vegetable farming, livestock husbandry, fishing, or fish cultivation, all of which depend heavily on water. With the erection of the Formosa Plastics Corporation's (FPC) sixth naphtha cracker complex on reclaimed land near the coast, the environment has become seriously damaged. Water has become scarce and underground water has been over-pumped for agricultural and industrial use, resulting in low-levels of underground water and inundation by seawater. Industrialization has complicated these environmental problems. For example, air pollution and water pollution have increased, which in turn have caused acid rain and the destruction of ocean ecology. Fish catches have also decreased. It is important to examine local vulnerability to mitigate any environmental disaster whether it is an earthquake (Ma & Ohno, 2013), typhoon or water-related problems.

Past studies of environmental problems in coastal areas tended to focus on hydraulic engineering. Not many papers have investigated the perception of the general public toward the specific problems associated with water in the coastal area. Of the few studies that did, most tended to focus on the attitudes and behavior of students toward the general environmental problems of the local area (e.g.,Wu Ya-wen, 2006). The purpose of this study, therefore, is to try to understand people's perceptions, attitudes, and opinions of the local water issues and includes the following specific objectives:

- To identify local environmental problems related to water in the Mailiao area.
- To investigate residents' perceptions of the existence of these identified problems in the Mailiao area.
- To investigate residents' perceptions of the seriousness of these environmental problems.
- To investigate residents' perceptions of the seriousness of the consequences these environmental problems incur.
- To investigate residents' opinions about whether the problems can be solved using scientific methods or technology.
- To investigate residents' opinions about whether the situation can be improved within the next 10 years.
- To investigate residents' willingness to change their lifestyle to alleviate the environmental problems.

2. Method

To identify local environmental problems related to water, we first observed the local environment, recording visible evidence of problems with pictures. We then searched texts, newspapers, and the internet to identify the problems that were not readily apparent. Finally, we examined scholarly works relating to local environmental problems.

Through direct observation and a literature review, sixteen local environmental problems were identified. These problems included poor drainage (retrieved from http://gisapsrv01.cpami.gov.tw/cpis/cprpts/yunlin/depart/facility/ch2-2.htm); flooding (retrieved from http://e-info.org.tw/node/25832); inundation by sea water (retrieved from http://e-info.org.tw/node/67742); erosion of the coastline (retrieved from http://e-info.org.tw/node/2923); movement of sandbanks (retrieved from http://e-info.org.tw/node/23127); river and water pollution (visual observation; retrieved from www.appledaily.com.tw/realtimenews/article/life/20120627/129459); ocean pollution (retrieved from

http://shuchuan7.blogspot.tw/2007/11/blog-post_15.html); acid rain (retrieved from http://www.libertytimes.com.tw/2010/new/jul/27/today-fo8.htm); the decrease of fish catches (retrieved from http://e-info.org.tw/node/28190); the destruction of ocean ecology, (retrieved from http://e-info.org.tw/node/28190); lack of water for use in agricultural and industrial activities; lack of water for livelihoods; over-pumping of underground water (Lee, 2011); resulting in the low level of underground water (Lee, 2011); subsidence (retrieved from http://e-info.org.tw/node/67742); and the disappearance of natural beaches (retrieved from http://www.cpami.gov.tw/pda_chinese/index.php?option=com_content&view=article&id=14251&Itemid=142).

Accessibility to the coastal area reclaimed and occupied by the FPC complex is strictly forbidden; thus, the geographic change of the coastline and the degree of water pollution were not able to be investigated, limiting our study in this respect.

2.1. Measurement

Sako, T., Hirata, S., & Gifford, R. (1998) developed an Environmental Appraisal Inventory (EAI) based on the personal appraisal of environmental hazards and a sense of control. The scale adequately evaluates awareness of and attitudes toward environmental problems and has been found to possess construct validity as a tool for measuring environmental awareness.

To investigate residents' perceptions of the problems, questions were either drawn or modified from the measurements of previous works (e.g., Environmental Appraisal Inventory developed by Sako et al., 1998, and scales developed by Duan, H. & Fortner, R.W., 2005). There were 6 questions in total, resulting in a scale that measured environmental perception related to local water problems.

With the exception of Q2, the scale used a 5-point Likert scale with responses of strongly agree, agree, neutral, disagree, and strongly disagree. The questions were modified to fit the agree/disagree format. Table 1 shows the questions of the scale. Scores were scaled to 5-1 to match the 1-5 scoring. In Q2, the respondents were asked to rate the three most serious problems among the sixteen issues. The most serious problem obtained 5 points, the second obtained 4 points, and the third was given 3 points.

Table 1. Modification of measurement questions

	Sources	Modified Questions
1	How certain are you that the issue really does present a problem to the natural environmental or to human beings （Duan & Fortner, 2005）?	I am certain the issues present a problem to the local environment.
2		Which of the following issues do you consider to be the most serious environmental problem in Mailiao?
3	How serious do you consider the causes, processes, or consequences of the problem to be（Duan & Fortner, 2005）?	I consider the consequences of the problems to be very serious.
4	How will the environmental problem be 20 years from now（Duan & Fortner, 2005）?	I agree the environmental problems will worsen 10 years from now.
5	Will this phenomenon, do you think, be solved technologically in the future (Sako et al., 1998）?	I agree this phenomenon will be solved technologically in the future.
6	To solve this phenomenon, do you think you must alter your life-attitude and lifestyle (Sako et al., 1998）?	To solve this phenomenon, I am willing to alter my lifestyle.

2.2. Questionnaire design

A survey was conducted using a questionnaire format. The questionnaire consisted of two parts. The first part consisted of a scale of environmental perception related to local water problems. The second part dealt with demographic characteristics of the respondents, including gender, age, and occupation. Age was measured in five categories: (1) under 25, (2) 26-35 years old, (3) 36-45 years old, (4) 46-55 years old, and (5) above 55.

2.3. Sample size

In the countryside, residents are generally less educated and more conservative. Young people usually leave their hometown for study, which made it difficult to find people of different educational background and ages to respond to the questionnaire. In the end, questionnaires had to be given to friends to help distribute. In past studies of perception using empirical methods, there was no specific consideration given as to how big the sample size should be for statistical validity. A general sample size of 100 to 350 was derived from the previous studies. A convenience sample of 450 was used to collect data in this study. Underneath is a diagram of the research framework and procedure (Fig.1)

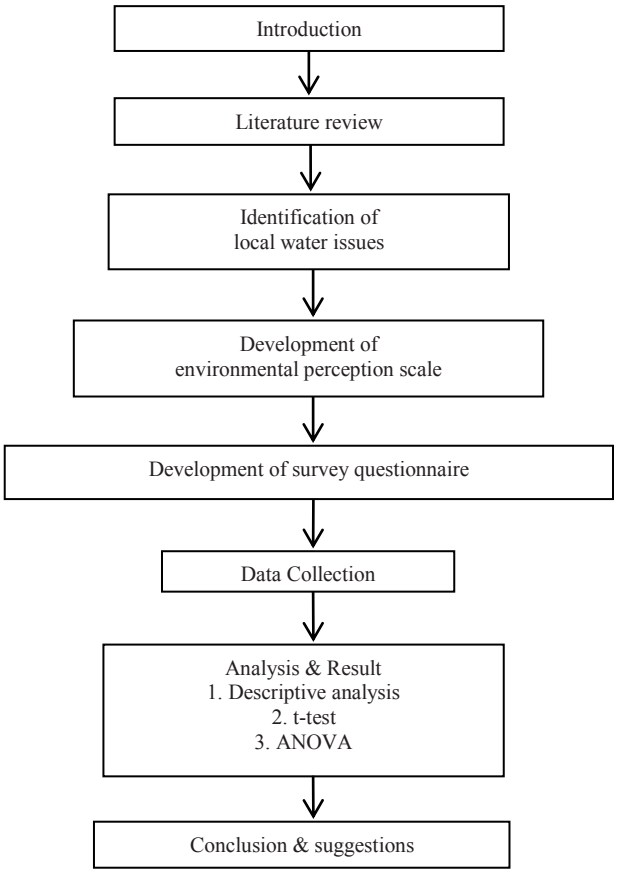

Fig. 1. Research framework and procedures

3. Results

3.1. Data collection

A total of 450 questionnaires were distributed to the subjects in June of 2008. 427 questionnaires were returned with a return rate 94.9%. 24 of the 427 were found to be invalid and were excluded, leaving a total of 419 valid responses. Out of the 419 respondents, 259 were male and 160 were female. Among these respondents, 56 were under 25 years old, 180 were between 26-35 years old, 95 were 36-45 years old, 52 were between 46-55 years old, and 36 were above 56 years old.

Sixteen environmental problems associated with water were identified in the Mailiao area, Taiwan. Six questions were asked in a survey format. The results are as follows.

Q1. I am certain the following issues present a problem to the local environment.

The residents in Mailiao were certain of the existence of these sixteen environmental problems (Table 2). The average mean scores of most of the problems were above 3.50, implying that the problems are real. Five problems (erosion of the coastline, the movement of sandbanks, and shortage of water for livelihood, agricultural and industrial use) had mean scores below 3.50, meaning that the residents were less sure about these problems.

Table 2. Certainty of environmental issues

Rank	Item No.	Environmental Issues	Mean	SD
1	#11	Subsidence	3.99	1.01
2	#13	Over-pumping of underground water resulting in the low level of underground water	3.89	1.08
3	#9	River pollution	3.87	1.01
4	#7	Ocean pollution	3.81	1.02
5	#14	Destruction of ocean ecology	3.81	1.05
6	#10	Decrease of fish catches	3.78	1.11
7	#2	Acid rain	3.77	0.97
8	#3	Poor drainage / inundation by the sea	3.77	1.06
9	#6	Flooding	3.76	1.01
10	#12	Disappearance of beaches	3.65	1.14
11	#15	Salted soil	3.56	1.04
12	#4	Erosion of the coastline	3.40	1.08
13	#1	Lack of agricultural water	3.37	1.05
14	#8	Lack of water for livelihoods	3.35	1.01
15	#5	Movement of sandbanks	3.35	1.10
16	#16	Lack of industrial water	3.25	1.11

That the residents were less sure about the erosion of the coastline and the movement of sandbanks is understandable. Pawlik (1991) identifies five inadvertent characteristics of environmental change that make it difficult for people to perceive the problems. Distance and proximity are one of the important factors in getting information about environmental risk. Since the coastal area in Mailiao is occupied by

the FPC factory complex, it is probably difficult for people to recognize the change along the coastline or the movement of the sand bank.

Subsidence and over-pumping of underground water are serious problems in this area, yet ironically, people did not feel a serious threat from the lack of agricultural water supply. A reasonable explanation is that the government has not regulated how deep farmers can pump for water underground: whenever there is a need for water, people just pump deeper. Another explanation is the difference of perception between farmers/fishermen and non-farmers/fishermen. 81.1％ of the respondents are not engaged in a farming or fishing business, compared to 18.9% of the respondents who are farmers and fishermen. The T-test found that there is a difference in their recognition of the problems [t (418)=-4.202，p<.05]. Thus, environmental education or media information is needed to arouse the consciousness and awareness of the people that cannot perceive the problems.

Q2. Which of the following issues do you consider to be the most serious environmental problem in Mailiao?

In this question, acid rain was ranked as the top issue, followed by subsidence, and then the over-pumping of underground water, resulting in the low level of underground water (Table 3).

Table 3. The most serious environmental problem related to water

Rank	Item No.	Environmental Issues	The most serious (3 points)	The most serious (2 points)	The third serious (1 points)	Total scores
1	#2	Acid rain ***	77x 3	42x2	26x1	341
2	#11	Subsidence **	41	51	41	266
3	#13	Over-pumping of underground water resulting in the low level of underground water *	38	32	44	222
4	#3	Poor drainage / Inundation by the sea	40	28	43	219
5	#7	Ocean pollution	36	42	25	217
6	#6	Flooding	34	38	23	201
7	#1	Lack of agricultural water	43	16	15	176
8	#9	River pollution	18	40	34	168
9	#14	Destruction of ocean ecology	23	26	46	167
10	#10	Decrease of fish catches	10	20	30	100
11	#12	Disappearance of beaches	14	18	18	96
12	#8	Lack of water for livelihoods	10	19	21	89
13	#4	Erosion of the coastline	5	5	8	33
14	#5	Movement of sandbanks	2	8	5	27
15	#16	Lack of industrial water	3	6	5	26
16	#15	Salted soil	1	5	10	23
		Total	395	395	395	2370

N=395，***The most serious、**the second most serious、*the third most serious

Acid rain has superseded the other issues to become the most serious problem in Mailiao. The air pollution produced by FPC causes acid rain which, in turn, pollutes the underground water and agricultural and fish products. It has also been found that there is a high correlation between pollution and the cancer and mortality rates in Mailiao and neighboring areas (retrieved from http://www.libertytimes.com.tw/2009/new/ jun/8/today-fo4.htm).

Q3. I consider the consequences of the problems to be very serious.

The residents considered the consequences of most of the problems to be serious (mean above 3.50). Of the problems, subsidence and the over-pumping of underground water resulting in the low level of underground water were viewed as the most serious (means= 4.04 and 4.03, respectively).

Table 4. The consequences of the problems

Rank	Item No.	Environmental issues	Mean	SD
1	#11.	Subsidence	4.04	0.89
2	#13.	Over-pumping of underground water resulting in the low level of underground water	4.03	0.90
3	#9.	River pollution	3.99	0.92
4	#10.	Decrease of fish catches	3.99	0.93
5	#3.	Poor drainage / inundation by the sea	3.96	0.93
6	#7.	Ocean pollution	3.96	0.94
7	#6.	Flooding	3.95	0.91
8	#14.	Destruction of ocean ecology	3.94	0.94
9	#2.	Acid rain	3.87	0.90
10	#15.	Salted soil	3.75	0.92
11	#12.	Disappearance of beaches	3.74	0.94
12	#1.	Lack of agricultural water	3.65	0.82
13	#8.	Lack of water for livelihoods	3.63	0.91
14	#4.	Erosion of the coastline	3.63	0.92
15	#5.	Movement of sandbanks	3.58	0.95
16	#16.	Lack of industrial water	3.45	1.06

Among the consequences of the environmental problems, those from subsidence and the over-pumping of underground water resulting in the low level of underground water in the area were deemed to be the most serious. Compared to the responses to Q2 in which acid rain was ranked as the most serious problem, the responses in Q3 revealed that respondents did not seem to consider the consequences of acid rain as being serious.

Q4. I agree the environmental problems will worsen 10 years from now.

Table 5. The worsening of environmental problems within 10 years

Rank	Item No.	Environmental issues	Mean	SD
1	#11.	Subsidence	4.15	0.82
2	#10.	Decrease of fish catches	4.09	0.86
3	#13.	Over-pumping of underground water resulting in the low level of underground water	4.07	0.87
4	#2.	Acid rain	4.04	0.85
5	#14.	Destruction of ocean ecology	4.03	0.88
6	#9.	River pollution	4.03	0.93
7	#7.	Ocean pollution	3.99	0.94
8	#15.	Salted soil	3.97	0.83
9	#12.	Disappearance of beaches	3.90	0.83
10	#3.	Poor drainage / inundation by the sea	3.86	0.96
11	#5.	Movement of sandbanks	3.86	0.85
2	#4.	Erosion of the coastline	3.84	0.86
13	#6.	Flooding	3.80	1.02
14	#8.	Lack of water for livelihoods	3.76	0.98
15	#1.	Lack of agricultural water	3.70	0.92
16	#16.	Lack of industrial water	3.66	1.01

When asked whether they thought the environmental problems would worsen 10 years from now, residents believed they would (means all above 3.5). Among the problems, subsidence, the decrease of fish catches, the over-pumping of underground water, acid rain, the destruction of ocean ecology, and river pollution were viewed as going to become much more serious (means all above 4.00).

Q.5 I agree this phenomenon will be solved technologically in the future.

Most residents believed the problems could be solved in the future using technology (means all above 3.50).

Table 6. Technological solution

Rank	Item No.	Environmental issues	Mean	SD
1	#9.	River pollution	3.89	0.93
2	#8.	Lack of water for livelihoods	3.87	0.89
3	#6.	Flooding	3.85	0.95
4	#7.	Ocean pollution	3.85	0.95
5	#3.	Poor drainage / inundation by the sea	3.84	0.92
6	#14.	Destruction of ocean ecology	3.80	0.94
7	#13.	Over-pumping of underground water resulting in the low level of underground water	3.80	0.98

Table 6. Technological solution (cont'd)

Rank	Item No.	Environmental issues	Mean	SD
8	#11.	Subsidence	3.77	0.97
9	#1.	Lack of agricultural water	3.76	0.90
10	#15.	Salted soil	3.75	0.90
11	#16.	Lack of industrial water	3.74	0.90
12	#10.	Decrease of fish catches	3.74	0.96
13	#2.	Acid rain	3.71	0.95
14	#12.	Disappearance of beaches	3.69	0.93
15	#4.	Erosion of the coastline	3.65	0.95
16	#5.	Movement of sandbanks	3.63	0.97

Q6. To solve this phenomenon, I am willing to alter my lifestyle.

When asked whether they were willing to change their lifestyle to solve the environmental problems, most of the residents showed a willingness to change.

Table 7. Willingness to alter lifestyle

Rank	Item No.	Environmental issues	Mean	SD
1	#8	Lack of water for livelihoods	3.94*	0.86
2	#14	Destruction of ocean ecology	3.90	0.88
3	#11	Subsidence	3.89	0.88
4	#9	River pollution	3.89	0.92
5	#13	Over-pumping of underground water resulting in the low level of underground water	3.89	0.89
6	#7	Ocean pollution	3.88	0.91
7	#6	Flooding	3.87	0.89
8	#3	Poor drainage / inundation by the sea	3.82	0.88
9	#10	Decrease of fish catches	3.81	0.92
10	#2	Acid rain	3.78	0.88
11	#1	Lack of agricultural water	3.75	0.82
12	#14	Destruction of ocean ecology	3.73	0.88
13	#12	Disappearance of beaches	3.71	0.90
14	#5	Movement of sandbanks	3.68	0.91
15	#4	Erosion of the coastline	3.67	0.89
16	#14	Lack of industrial water	3.60	0.99

4. Summary, discussion, and conclusion

Environmental problems related to water in the Mailiao area are serious, especially the shortage of a water supply. This problem had caused the land to sink, affecting not only the safety of the structure supporting the high-speed railway, but also the intrusion of salt water into the coastal area. An enormous amount of water is required for industrial and agricultural use, but in Taiwan, half of the year is dry with little to no rainfall. Although the government is building a new reservoir upstream, whether it will be enough is still questionable. When making policies, the government should consider the effect of climate change. Furthermore, air pollution created by industrialization has also affected the quality of sea water and underground water. The so-called economic development and job opportunities for the local people ironically bring disaster and further problems to the area.

It was interesting to observe that acid rain was perceived to be the most serious issue in the area, while the seriousness of the consequences it incurs was rated 9th. Apparently, the harmful effect of acid rain was not thoroughly observed or realised by the residents. The results showed that the residents were able to recognize effects that were tangible, directly impacted them, or were widely discussed and publicized.

However, when effects are intangible, indirect, or have a complicated process, they are less perceived. The residents were less aware of how air pollution causes acid rain and how acid rain affects rivers, underground water, plants, fish, the food chain, and the health of the human body. The effects of acid rain are actually more severe than those of subsidence and the low level of underground water, although they have not been "seen" by the locals. For problems that are beyond human perception, environmental education or media communication are needed to keep the public informed.

It is interesting to see the residents believed the problems would worsen in the next 10 years. This perception is possibly based on the present public's behavior. It is also interesting to see that people believe in technology (mean scores above 3.5). In the end, the residents agreed to alter their lifestyle in order to alleviate the burden on the land. However, how and to what degree will they change their lifestyle is a question. Are they willing to participate in water conservation measures? Are they willing to pay higher water prices or taxes? This all requires further study.

The results of this study provide insight into the problems involved.

- The results provide a warning against the over-development of coastal areas.
- For problems that are serious yet not perceived, mass-media communication and environmental education is necessary to awaken public consciousness.
- Technology and science may be a way to help detect and solve environmental problems.
- There is a need for the government to set a limit to growth, as well as initiate more environmental protection programs and restoration plans.
- Enterprises also need to change their values and assume more responsibility for environmental protection.
- Meanwhile, the residents can engage in more environmental behavior such as participating in public affairs and actively discussing the situation.

Although the issues tackled here are specific to a small area, many of them apply to other places in Taiwan and the world. This paper is a suitable reference for resource management studies and the establishment of environmental education programs.

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